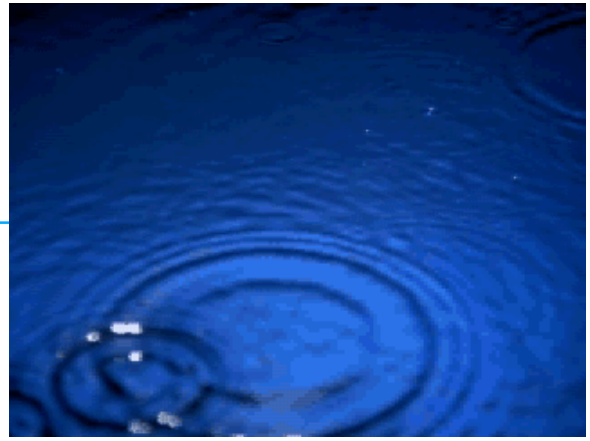
GPM

GLOBAL PRECIPITATION MEASUREMENT

Global Precipitation Measurement (GPM)

NASA GPM Ground Validation Development Status

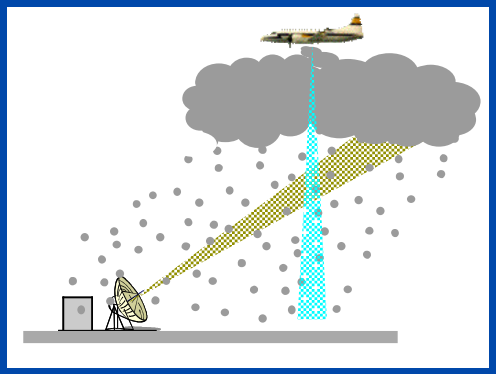
November 6, 2006



Mathew Schwaller
GPM Formulation Project
Ground Validation Manager
mathew.r.schwaller@nasa.gov

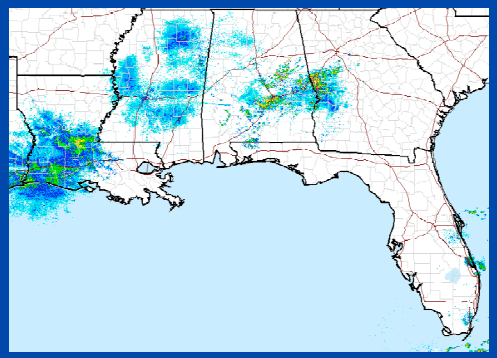
3 Scales of Measurement for GPM GV

Field Campaigns



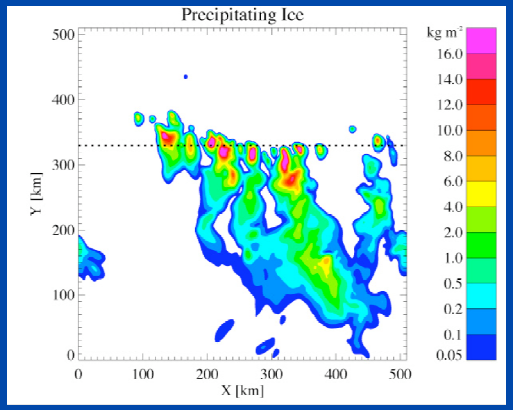
- From individual hydrometeors to radar/aircraft ensembles
- Several mm to 150km radius by 10 km high

Validation Network



- Measurements on the order of radar networks
- Individual radars with radii of 150-300km; networks with large regional to continental coverage

Satellite Simulation



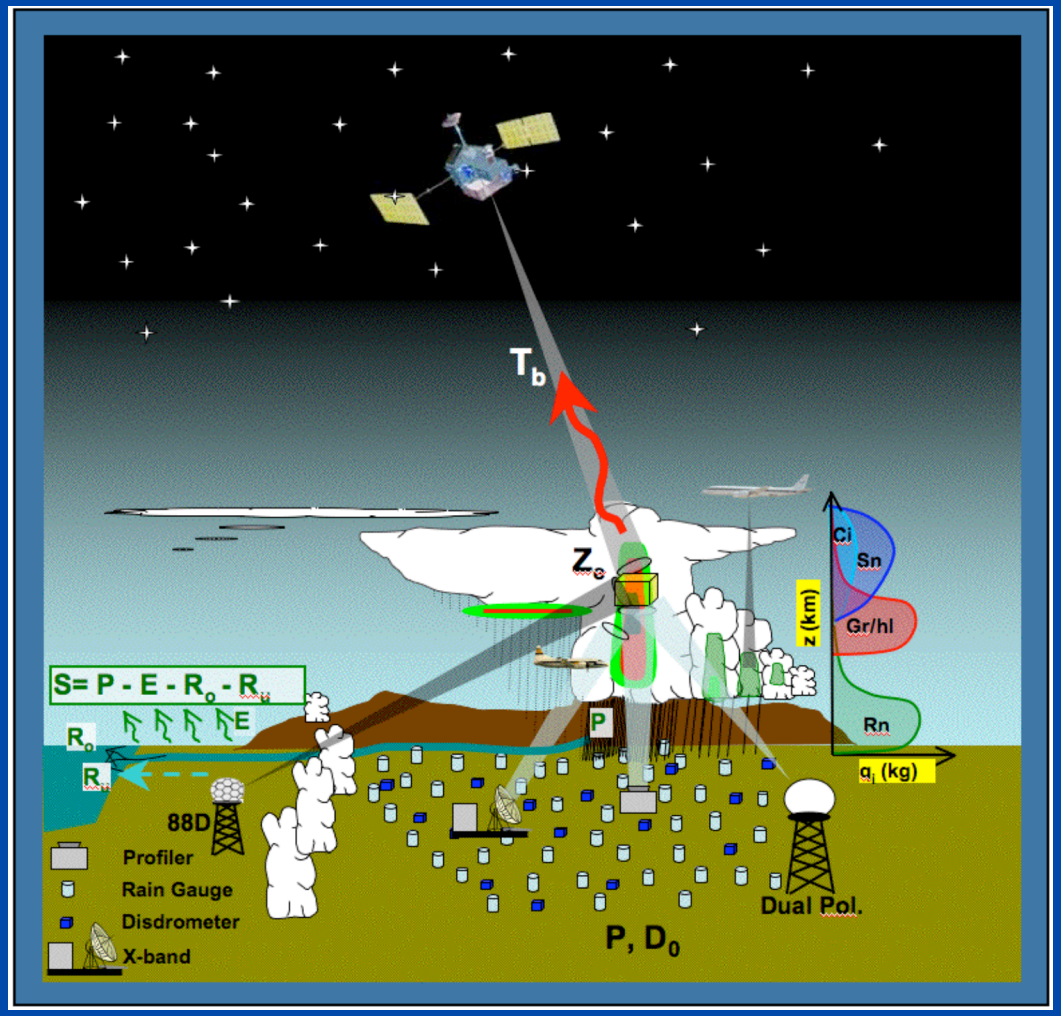
- Integrate measurements with radiative transfer models across all scales of GV measurement: from the earth-surface to top of the atmosphere
- Possibility of global expansion

The 3 Elements of GPM GV System

- **Field campaigns**
  - Goal: physical validation through precipitation and hydrological process studies
  - Planned to be operational 6 months prior to launch
  - Focused, in-depth study of atmospheric and land-surface variables that contribute to precipitation estimation, forecasting, and hydrological applications
- **Validation Network**
  - Goal: statistical validation of GPM/DPR raw and attenuation-corrected reflectivity
  - Leverages US national infrastructure of weather radars and rain gauges
  - Matches TRMM/GPM PR/DPR observations to ground radars
- **Satellite simulation modeling**
  - Goal: physical validation of GPM retrieval algorithms
  - Pre-launch: simulate GMI high-frequency and DPR Ka-band observations
  - Coupled system approach: land-surface through radiative transfer
  - Post-launch: validate the physical assumptions of GPM precipitation algorithms
- **Prototype development of these GV elements is now underway…**

Ground Validation Field Campaigns

- Planned as a series of Extended & Intensive Observation Periods (EOPs and IOPs)
- Focus on precipitation process studies and integrated science
- Study site locations leverage off of operational agency sites, candidates include:
  - DOE CART/SGP
  - NOAA's Hydro-meteorological Testbed
  - Other cooperative field operations are under consideration

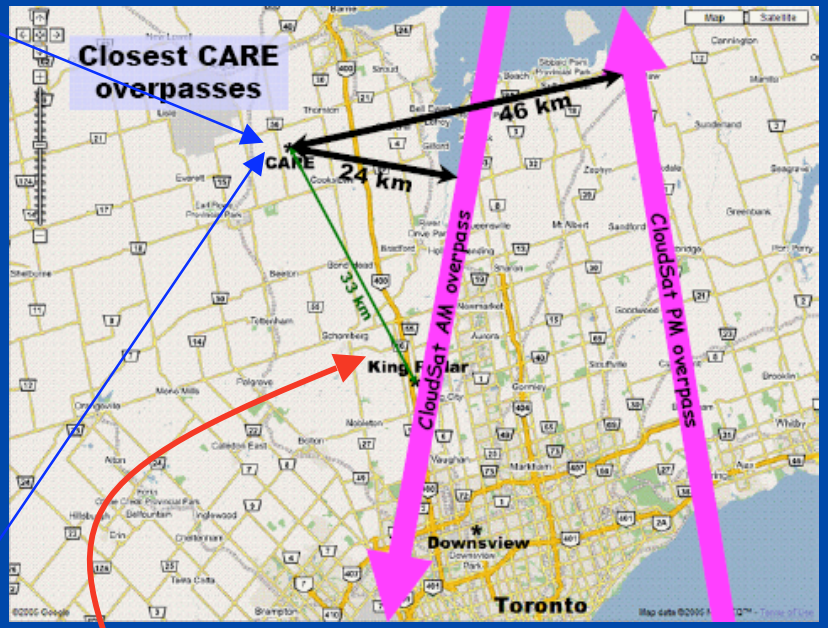


Winter 2006-2007 Field Campaign Prototype

- GPM and PMM Science Team is participating in the Canadian CloudSat/CALIPSO Validation Programme (C3VP)
  - Per suggestions of GPM GV Science Panel: GPM/PMM goal for early tests and evaluation of snow and mixed-phase retrieval algorithms for GPM GMI and DPR
- C3VP is organized by the Meteorological Service of Canada, with major contributions from
  - NASA/JPL CloudSat Project
  - DoD Center for Geosciences/Atmospheric Research at Colorado State University (Cloud Layer Experiment-10, CLEX-10)
  - McGill and other universities
- C3VP has four Intensive Operations Periods (IOPs) with instrumented aircraft
  - IOP-1: October 31 - November 9
  - IOP-2: November 30 - December 11
  - IOP-3: January 17 - January 28
  - IOP-4: February 18 - March 1
  - Ground observations now underway — ending March, 2007

C3VP Operations at "CARE"

Centre for Atmospheric Research Experiments (CARE) site located ~70km north of Toronto



Instrument array including radars, disdrometers, gauges, radiometers, radiosonde launches

King City C-Band Radar ~30km from CARE (10 minute scan cycle)

Campaigns include Convair C580 aircraft flights during IOPs and Regional Atmospheric Modeling System (RAMS) output

NASA's Contributions to C3VP

- Advanced Multi-Frequency Radar (AMFR)
  - University of Massachusetts (Paul Siqueira and Nino Majurec)
  - High resolution, 3-frequency (Ka, Ku, W), truck-mounted
  - Deployed during C3VP IOP-3 (January 2007)
- 2-Dimensional Video Disdrometer (2DVD)
  - Colorado State University (V.N. Bringi)
  - Measures hydrometeor concentrations, sizes (equivalent diameter), shapes, and fall speeds
  - Deployed during C3VP IOP-3 (January 2007)
- Two Parsivel Laser Disdrometers
  - NASA/Goddard Space Flight Center Science & Exploration Directorate (Codes 613 & 614)
  - Measures hydrometeor numbers, sizes (maximum width), and fall speeds
  - Deployed during majority of the winter 2006-2007 at CARE
- Deployments supported by NASA's Precipitation Measuring Mission Science Team and by the GPM Project

More C3VP Instrumentation

Ground Instrumentation at CARE

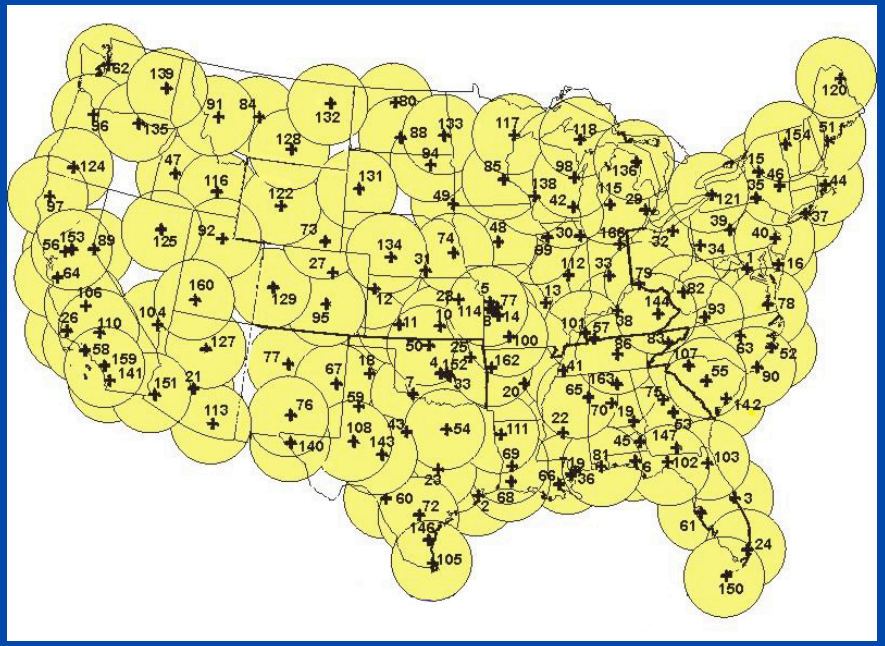
Affiliation	Sensor / System	Measurement
NASA/JPL	W-band polarimetric radar	Cloud phase, particle type, precip rate
UMass	Adv Multi-Freq Radar (U, Ka, Ku-band)	Cloud phase, particle type, precip rate
EC	Ceiliometer	Geometric cloud profile
McGill	X-band VertiX Doppler radar	Cloud detection, particle type
McGill	Video disdrometer	Precip fall velocity and shape, DSD
CSU	2D video disdrometer	Precip fall velocity and shape, DSD
NASA/GSFC	Parsivel laser disdrometer	Precip rate, precip type, DSD
EC	POSS	Precip rate, precip type, DSD
EC	Hot plate	Precip rate
EC	Geonor precipitation gauge	Precip rate
EC	Visibility meter	Visibility, present weather indicator
EC	10m met tower	P, T, RH, wind
EC	TP/WVP-3000 profiling radiometer	LWP
NASA/GRC	89 & 165 GHz profiling radiometer	LWP w/ sensitivity to ice particles
EC	915MHz wind profiler w/ RASS	Wind profile, turbulence, temp profile
EC	Vaisala radiosonde system	P, T, RH, wind profiles
EC	Broadband radiometers	Pyranometer & pyrgeometer
Penn State	Dual-radiometer package	Cloud optical depth
McGill	Ground particle photography	Particle imaging & sample collection

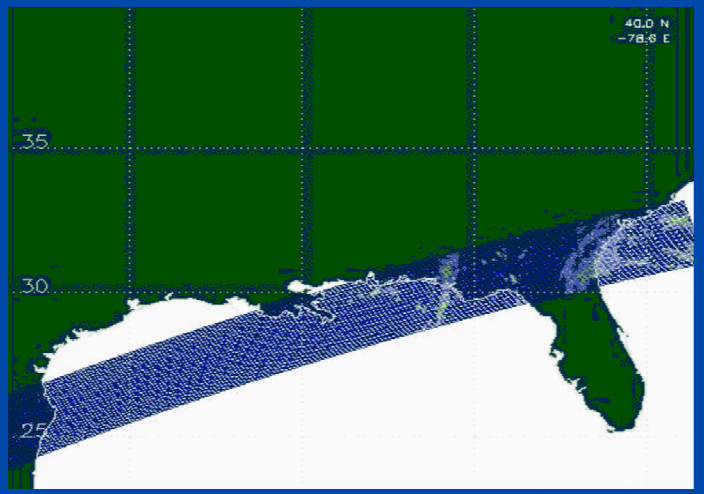
Convair aircraft instrumentation

Cloud Spectrometers (underwing pylons)	Other Instrumentation
PMS PCASP-100X probe (0.31.0 μm)	AERI AL (AERosol Imaging Airborne Lidar)
PMS FSSP-300X probe (0.230 μm)	Ka band radar (non-polarimetric, non-doppler)
2 PMS FSSP probes (2-47 μm, 5-95 μm)	NRC X-band/W-band polarimetric radar
PMS 2D-2C probe (25 800 μm)	Broadband Visible and Infrafred Radiometers
SPEC 2D-S probe (10 1280 μm)	Extinction probe
PMS 2DC-grey probe (15 960 μm)	Ice Nucleus Counter (CSU)
DMT CIP probe (12.768 μm)	Rosemount Ice detector
PMS 2D-P probe (200-6400 μm)	TAMDAR (winds, turbulence, temperature, relative humidity, icing)
SPEC HVPS probe (200-25000 μm)	

Ground Validation Network

- Goal: Identify and resolve significant discrepancies between the US national network and satellite estimates
- Use available national resources including radars and rain gauge networks
- Identify systematic discrepancies in GPM products.
- Additionally:
  - Understand (and minimize) the errors associated with the geometry and timing of joint satellite and ground observations
  - Quantify the bias and errors contributed by individual ground and space-based instruments
  - Contribute to an error model of precipitation measurements
  - Assess the first order errors of satellite rainfall retrievals over land





Validation Network Prototype

- Prototype just getting started with 20 NEXRAD sites in southeast US
- Success criteria

  Pre-launch

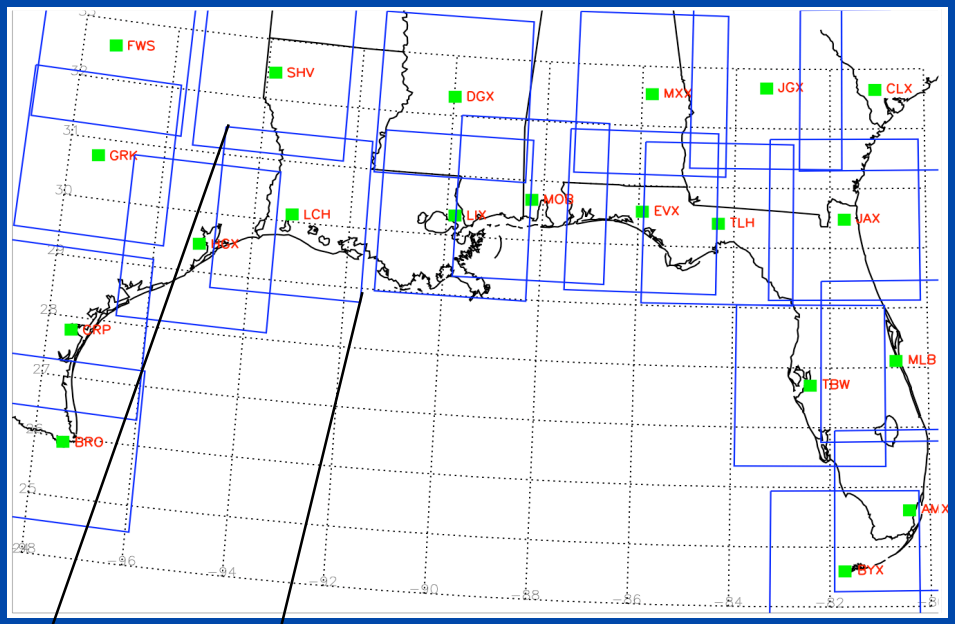
  – Validate PR-to-NEXRAD radar reflectivity calibration and PR attenuation correction (based on approach by Bolen & Chandrasekar)

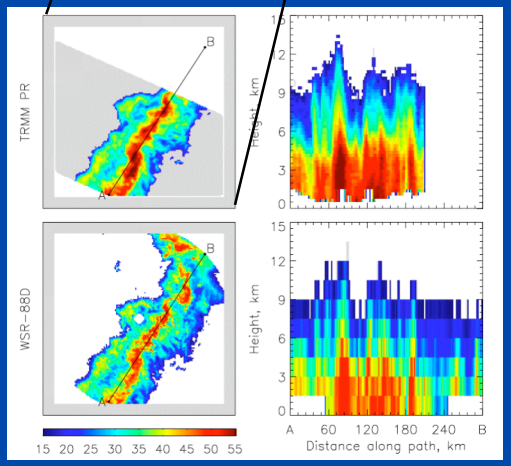
  – Experimental product for comparison of NEXRAD and PR estimates of rain rate and D_O (median drop diameter)

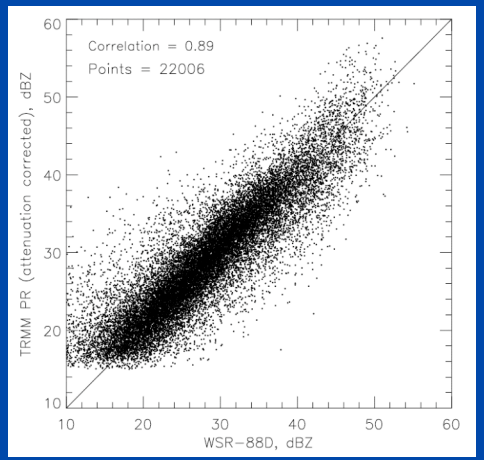
  – Validate scalability to all NEXRADs and other radars

  Post-launch

  – Pre-launch working products applied to DPR Ka / Ku bands and to GMI







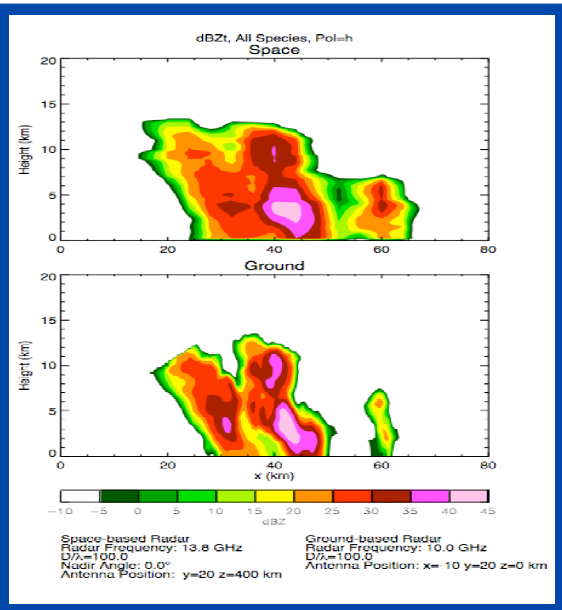
L. Liao & R. Meneghini

GV Satellite Simulator Model

- Goals & Objectives
  - Validation/verification of the physical basis for the PMM algorithms
  - Assess sources of error in comparing ground measurements with PMM data products due to: sample volume mismatch, space/time offsets, and different instrument/retrieval methods
- Implementation Approach
  - A high-resolution CRM generates hydrometeor fields and other data (e.g., aerosols, temperature, humidity,…) needed to run the forward model
  - DPR simulator calculates radar reflectivity at range gates through the model atmosphere
  - GMI simulator calculates TOA radiances
  - DRP and GMI algorithms generate retrievals of R
  - DPR algorithm also generates retrieval of Do
  - Spacecraft R and Do are compared (initially) to ground instrument simulations and to field campaign ground measurements
  - Coupled CRM/Land-Surface Models to address water cycle

GV Satellite Simulator Demonstration

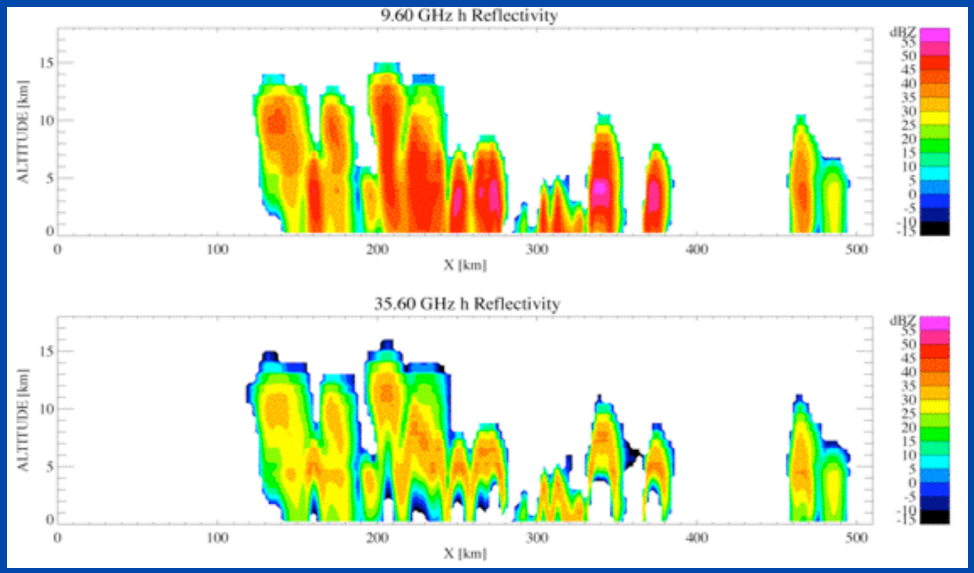
- Proof-of-concept simulation of ground, airborne and satellite instruments
  - A high-resolution CRM generates hydrometeor fields and other model parameters needed to run the forward model
  - DPR simulator calculates radar reflectivity at range gates through the model atmosphere
  - GMI simulator calculates radiance fields, including TOA radiance; extended to simulate airborne radiometer and radar observations
- Future development includes retrievals of R and Do, coordination with EarthCARE simulator



DPR Ku-band attenuation corrected

Ground X-band attenuation corrected

(R. Meneghini)



W. Olson and M. Grecu

Last Slide: Sketch of GPM GV Development Plan

- Science Advisory Process
  - Advisory panel provides recommendations on GPM GV scope & direction
- System Documentation & Reviews
  - Ground Validation System design documents available in draft form
    - > Requirements, operations concepts and system architecture to be completed by Mission PDR (September 2008)
    - > Mission CDR scheduled for September 2009
- Risk Reduction Prototypes
  - Field campaign prototype (C3VP)
    - > Campaign had just started, will conclude in March 2007
    - > Data will be available to the PMM Science Team and other C3VP team members; all data publicly available 3 years after campaign
  - Validation network prototype
    - > Corresponding NEXRAD and PR subsets expected to be available on a public web site in the new year; comparison products to be added over time
  - Satellite simulator prototype planned but not yet scheduled
- GV System Implementation
  - GPM GVS will be fully operational 6 months prior to GPM launch